Pattern Detection in Visual Fields for Glaucoma Using Two Types of Unsupervised Learning With Machine Learning Classifiers

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Background: Glaucoma is a treatable blinding disorder that affects as many as 100 million people worldwide. Detection of glaucoma and of its progression is designated to be of paramount importance by the Vision Research Plan published by the National Institutes of Health. The most common and widespread test for glaucoma is the visual field, currently in the form of computerized standard automated perimetry (SAP). In previous studies, we found specific machine learning classifiers (Support Vector Machine and Mixture of Gaussian) to equal or exceed glaucoma experts and statistical classifiers for diagnosing glaucoma from SAP (selection criterion 1). **Purpose**: We aim to find patterns of visual field defects in SAP that are used by machine learning classifiers for diagnosis and to compare these patterns with those used by visual field experts. **Methods**: The SAPs came from 189 normal eyes and 156 eyes with glaucoma, as indicated by the presence of glaucomatous optic nerve damage. Variational Bayesian Mixture of Factor Analysis (vbMFA) produced 5 clusters, one containing mostly normal visual fields and the other four almost entirely from eyes with glaucoma. Variational Bayesian Independent Component Analysis (vbICA) yielded 2 clusters, one mostly normal eyes and one almost entirely glaucomatous eyes. The glaucomatous cluster was decomposed into maximally independent axes. **Results**: The visual fields from the cluster of normal eyes had no significant defects in either vbMFA or vbICA. The generated mean visual field pattern for the 4 clusters of glaucomatous eyes derived by vbMFA corresponded to patterns determined by glaucoma experts to indicate the presence of glaucoma. These were localized defects, superior hemifield defects, inferior hemifield defects, and combined superior and inferior hemifield defects. These defects had the shape of patterns described by glaucoma experts: nasal step and arcuate defects. The cluster of fields from glaucomatous eyes was decomposed with vbICA into 6 maximally independent axes through the mean of the glaucoma cluster. Patterns varied from negative to positive standard deviations along each of the 6 axes: 1) full field defects to localized defects, 2) superior to inferior field loss, 3) temporal wedge to nasal hemifield loss, 4) paracentral defects to eccentric donuts, 5)nasal steps to arrow shaped depression, 6) nasal inferior to nasal superior defects. **Discussion**: With supervised learning, machine learning classifiers have the benefit of knowing the correct diagnosis of each field during the learning phase. The goal of these classifiers is to learn how to distinguish between fields from glaucomatous and normal eyes. Unsupervised learning does not have knowledge of the diagnosis during learning. The goal of those classifiers is to separate the patterns in some meaningful way. That these two vastly different methods of unsupervised learning found visual field patterns of glaucoma familiar to glaucoma experts from over 100 years cumulative experience validated the ability of machine learning classifiers to detect significant patterns (selection criterion 5). The finding of patterns not previously appreciated by glaucoma experts suggests that machine learning classifiers can increase the knowledge of experienced experts. These pattern groupings have the potential of pointing out the way glaucoma defects worsen as the disease advances.

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